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Retaining Open Space with Purchasable Development Rights Programs

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This paper examines the preservation of farmland through purchasable development rights. In a comparison of the estimated costs and benefit associated with the development of open space from 1982 to 1992, we show that these programs may provide a net benefi to society. An econometric model is employed to address the question of what factors explain both the creation of these programs and the magnitude of farmland preservation. Elasticity measures derived from the model indicate that a wide range of ecological and sociological variables are important in explaining the activity in purchasable development rights programs.

Much of the debate regarding land use changes in recent years has focused on urban sprawl. In many urban areas, the rate of growth in developed land has far exceeded the rate of growth in population.[1] Urbanized areas that include central cities and adjacent metro areas have grown from 106 to 369, expanding their area by 500% since 1950. Over the same time period, population density in urbanized areas has dropped 50% from 5,400 to 2,600 people per square mile. Much of this land that has been developed or is under threat of development is or was used for agriculture. Metropolitan Statistical Areas, define by the U.S. Bureau of Census, contain 20% of the U.S. land area, 80% of the U.S. population and 30% of all U.S. farms as of 1991. According to an American Farmland Trust study, one million acres of "top quality" agricultural land is converted to urban uses every year.

The European term "multifunctionality" (Mullarkey, Cooper, and Skully) applies to undeveloped agricultural land because it serves multiple functions besides production of food and fibe . These include preserving family farms and rural landscapes, ensuring food safety, food security, and animal welfare. Development erodes the aesthetic and environmental value of undeveloped land. This is documented by several studies showing that the public is willing to pay

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signif cant sums to preserve agricultural land at the local level (e.g., Bergstrom, Dillman, and Stoll; Beasley, Workman, and Williams; Bowker and Didychuk; Krieger).

Many of the environmental and aesthetic benef ts of open space have the classic traits of nonrivalry and nonexcludability of public goods. These traits imply that open space will not be supplied by the market in socially optimal amounts. As pressure for development rises, environmental and aesthetic benef ts will not be incorporated into the value of the undeveloped land parcel. This may lead to a shortage of open space.

Over the past several decades, institutional mechanisms have evolved to address the problem of diminishing open space (primarily agricultural land) near urban population centers. These institutional mechanisms, appearing primarily at the local (county and state) level, are both regulatory- and market-based. Regulatory-based measures include right-to-farm laws, reductions in real estate tax rates, zoning, urban growth boundaries, and the formation of agricultural districts. The primary market-based mechanism is the purchase of development rights (PDR) programs. These programs involve farmers selling the right to develop their land to a local authority.

Although additional Federal funding is now available for PDR programs, the source has typically been states or counties.[2] Parks and Schorr note that regulatory institutions such as zoning and market-based institutions such as PDR programs are more appropriate for preserving open space in metropolitan areas than direct government intervention (i.e., the Conservation Reserve Program). Kline and Wichelns (1994) investigated factors that inf uence public support for PDR programs. They found that the programs tend to occur in localities with increasing population and housing costs.

The objective of this paper is to determine what factors explain both the creation of these programs and the magnitude of land preservation. Elasticity measures derived from an econometric model indicate the important ecological and sociological variables explaining the activity of PDR programs.[3] Several of these variables coincide with existing theories. Before describing the model, we provide some motivation as to why these programs are worth considering by examining the potential costs and benef ts of preserving open space. A simple benef ts transfer exercise illustrates the potential nonmarket value of open space that was developed over a 10-year period (1982 to 1992) in the United States. These benef ts are compared with the potential costs of preserving land by purchasing development rights. Although crude, the exercise demonstrates that these programs may provide a net benef t to society.

The Nonmarket Benefits and Preservation Costs of Open Space

Open space provides amenities that are not fully valued in the marketplace. Individuals may derive pleasure from using these lands for recreational purposes, viewing these lands from a distance, or knowing that these lands are being protected from development. Several contingent valuation studies document the public's willingness to pay to preserve open space. These studies occur in small geographic areas, giving an incomplete picture of what open space amenities are worth nationally. In this section, a simple benef ts transfer approach is used to determine the value of open space developed over 1982–1992 in the United States. These benef ts are compared with the estimated costs of preserving this land by purchasing development easements.

The f rst step in the exercise involves using the National Resources Inventory (NRI) database to identify the amount of recently developed open space. The NRI is a large geo-referenced data set of all non-federally owned land in the United States. Each datum, or "point," is a homogenous (in terms of cover and use), privately held parcel of land that varies in size. The same points have been visited in three consecutive survey rounds in 1982, 1987, and 1992. Recently developed land is identif ed by comparing points that were reported developed in 1992, but not in 1982 (i.e., 1982 land use indicated cropland, pasture/range, or forest while 1992 land use indicated urban).

Obviously, proximity to population centers has an impact on development patterns. To examine this, each point is assigned into one of four urban inf uence categories (none, low, medium, and high).[4] About a third of the counties in the United States (1062 out of 3077) have some land in either the low, medium, or high urban inf uence categories (table 1). The actual amount of land in each urban inf uence category and land use from the 1992 NRI is the f rst number in each cell. Below this, in parenthesis, are the acres that were developed during 1982 to 1992. Across urban inf uence categories, the vast majority of land (81%) is in the lowest (none) urban inf uence category. The remainder is split approximately evenly across the low, medium, and high urban inf uence categories. While a signif cant amount (acres) of development occurs in the lowest urban inf uence category, it is a small percentage of the land in this category (0.4%). In percentage terms, the low, medium, and especially the high urban inf uence categories have much larger development rates. The most development, in terms of acreage (5.4 million) and percentage (6.7%) occurred in the high urban inf uence category.

The next step is to f nd empirical evidence of the value of preserving land from development. A review of the nonmarket valuation literature results in six studies that are candidates for a benef ts transfer exercise. All of these studies use the stated preference method to examine the benef ts of preserving farmland from preservation (table 2). For purposes of comparison, the average annual household value of preserving 1,000 acres of farmland (converted to year 2000 dollars) appears in the last column.

The column "Good Valued in Survey" describes what land the respondents were asked to value in the stated preference survey. These values vary considerably and are likely to be affected by the study location. The Beasley, Workman, and Williams and the Halstead studies were conducted in areas with scarce farmland that is ref ected by relatively high value estimates. The Ready, Berger, and Blomquist study focuses on preserving horse farms—a more specialized use than generalized agricultural land. The Bergstrom, Dillman, and Stoll and the Bowker and Didychuk studies were conducted in rural agricultural areas while the Krieger study was conducted in an agricultural area bordering a large city (Chicago). All of the studies concentrate on the willingness to pay to preserve agricultural land located near the respondent's residence.

The wide variance in willingness-to-pay numbers suggests that the value of open space is inf uenced by location and quantity (table 2). As the supply of

Table 1. The benefits and costs of preserving land threatened by urban sprawl[1]

Potential Area Impacted[2] (Amount Developed)	Urban Influence Category[3] (1,000 Acres)				Benefits[4] (Annual WTP—$ Billion)	Costs[5] (Total PDR Cost—$ Billion)
	None	Low	Medium	High		
Cropland	286,564	30,179	30,690	33,840	1.39	13.65
(developed)	(1,062)	(352)	(512)	(1,753)		
Pasture/range land	447,734	28,424	25,077	21,299	1.79	5.75
(developed)	(1,351)	(472)	(553)	(1,713)		
Forest land	318,458	26,025	22,370	25,643	2.12	8.53
(developed)	(1,834)	(571)	(691)	(1,946)		
Total	1,052,756	84,628	78,137	80,782	5.30	27.93
(developed)	(4,246)	(1,395)	(1,756)	(5,412)		

[1]Estimates of open space threatened by urban sprawl, the amount developed, the annual willingness to pay to forgo development and the cost of purchasing development rights. Source: 1992 NRI, USDA June Agricultural Surveys.
[2]Land in cropland, pasture/range, and forest that has not been developed as of 1992. The numbers in parenthesis are the acres that were in these uses in 1982, but are now in urban uses.
[3]Urban inf uence category measures development threat.
[4]Total annual willingness to pay (in year 2000 dollars) for preserving land that has been developed (in parenthesis) in each row. The "none" urban inf uence category is not valued.
[5]One-time cost of purchasing the development rights for land that has been developed (in parenthesis) in each row. Land in the "none" urban inf uence category is assumed to have zero development value.

Table 2. Estimates of the average amenity value of farmland[1]

Study	Geographic Area	Good Valued in Survey	Annual Value per 1,000 Acres per Household (Dollars)
Bergstrom, Dillman, and Stoll	South Carolina	Preserve agricultural land in Greenville County, SC	\$0.21–\$0.54
Beasley, Workman, and Williams	Alaska	Preserve agricultural land in Alaska	\$17.56
Halstead,	Massachusetts	Preserve "nearby" agricultural land	\$17.82–\$49.80
Ready, Berger, and Blomquist	Kentucky	Preserve horse farms in Kentucky	\$4.34–\$4.94
Bowker and Didychuk	New Brunswick, Canada	Preserve agricultural land in New Brunswick, Canada	\$1.08–\$2.45
Krieger	Illinois	Preserve agricultural land in 3 counties near Chicago	\$2.93

[1]All estimates are determined using the contingent valuation method with exception to the lower Ready, Berger, and Blomquist value, which used the hedonic property value approach. These are average per household values inf ated to year 2000 dollars using the April 2000 CPI.

open space diminishes, its marginal value is likely to increase. For this reason, several values from table 2 are used in an attempt to capture these changes. Open space in areas in the low or medium urban inf uence category are assigned the lowest possible value of $0.21 per 1,000 acres from Bergstrom, Dillman, and Stoll. In the high urban inf uence areas other than the northeast, the Krieger value of $2.93 per 1,000 acres is used. The Halstead value of $17.82 per 1,000 acres is used in the high urban inf uence areas of the Northeast.[5] Because all the studies appearing in table 2 concentrate on valuing agricultural land located in close proximity to the respondents, it is assumed that the public is only willing to pay to preserve threatened open space in their county of residence. In each county, the total county willingness to pay ($CWTP_i$) to preserve open space that has been developed is

$$(1) \qquad CWTP_j = (W_1 * L_{1j} + W_2 * L_{2j} + W_3 * L_{3j}) * H_j,$$

where j indexes the county, L_{ij} is land developed between 1982 and 1992 in the ith urban inf uence category (low, medium, or high) with corresponding willingness to pay W_i, and H_j is the number of households in the jth county.

The national willingness-to-pay (WTP) estimates appear in the "benef ts" column of table 1. The estimates are subdivided according to three NRI land use categories: cropland, pasture/range land, and forestland. Although the benef t studies in table 2 focused on agricultural land, it is assumed that forestland is also desirable and has a similar preservation value. Across agricultural land (crop and pasture/range combined), WTP is approximately $3.2 billion per year. Adding forestland raises the WTP to approximately $5.3 billion per year.

The last column in table 1 shows estimates of the costs of buying development rights easements on the land that was developed. These costs are determined using land value data from the National Agricultural Statistics Service's June Agricultural Surveys (JAS). The JAS is an area-frame stratif ed sample covering 1994, 1995, and 1996. The pooled sample size consists of more than 75,000 observations that are geo-referenced to the approximate parcel location and identif ed by land use (cropland, pasture, or forest). Respondents report a variety of information, including their estimate of the market value of land parcels they own or operate.[6] Geo-referencing allows each observation to be assigned into one of the four urban inf uence categories (none, low, medium, or high) described earlier. It is assumed that the prices of parcels in the "none" urban inf uence category ref ect the value of the land in agricultural use and are devoid of any development value. Parcels in the other three categories are assumed to have both agricultural use value and development value. The sum of these two components is the market price of these parcels. In each individual state and for each land use classif cation,[7] an average agricultural use value (dollar per acre) was computed using the prices of parcels in the none urban inf uence category. Next, development values for each land use group in each urban inf uence category (low, medium, and high) are computed by averaging the difference between market value and the agricultural use value (which is the price of land in the none urban inf uence category). This is the assumed price per acre of a development easement. The total cost of the development easement (table 1) is computed by multiplying the acres in each urban inf uence category and land use category by the corresponding development value (easement cost) and then summing across land use categories, urban inf uence categories, and states.

The costs of buying development rights (table 1) on agricultural land (crop, pasture, and range lands) are $19.4 billion. Costs associated with forestland are $8.5 billion, bringing the total cost to protect all land from development to $27.9 billion. While these costs appear to vastly outweigh the benef ts, it is important to note that the benef ts shown in table 1 are on an annual basis while the costs are incurred in a single time period. In theory, once development rights easements are purchased, the land is protected from development indef nitely. Annual benef ts of $5.3 billion will outweigh the costs of $27.9 billion in as little as 6 years.

Several caveats apply to the benef t–cost analysis above. First, although three WTP estimates are transferred in attempts to capture the increasing marginal value of open space resulting from scarcity, the transferred WTP estimates are average, not marginal. Second, the studies used concentrate on agricultural land, not all open space. Third, it is not clear from these studies exactly how much land is being valued (i.e., there may be scope problems). Fourth, the change in development in this exercise is not instantaneous; it occurred over a 10-year period. Fifth, the farmland value estimates are opinions of the owners or operators, and are not based on actual sales data. Lastly, forestland is valued at farmland WTP estimates. It is likely that forestland has a much higher preservation value. Unfortunately, no usable estimates of the value of preserving forestland from development could be located in the literature.

Despite these caveats, it should be noted that the transferred WTP ranges are based on the lower range of numbers that have appeared in the literature. The analysis also assumes that individuals place no value on preserving open space outside their county of residence or in areas that are deemed to have no urban inf uence. Even under these conservative assumptions, it appears that the benef ts of preserving open space might be quite large[8] and compare favorably with the cost of these programs. Clearly, it is unlikely that $28 billion will be spent on PDR programs in the near future, even at the national level. However, these programs continue to grow over time and evidently provide net benef ts to communities who fund them. The next section examines factors leading to the creation of these programs and to the amount of land that is preserved from development.

Determinants of Farmland Preservation Programs

To protect farmland from development, state and local (county) institutions have evolved across the United States. Some of these institutions are regulatory such as “right to farm” laws, differential tax assessment programs, and zoning laws. These laws protect farmers from nuisance lawsuits, assert that commercial agriculture is important to the economy, and protect farmers from paying taxes on land that may have high nonagricultural value. Most states have these regulations in one form or another. A successful market-based institution used to protect farmland that is empirically investigated here is the purchase of development rights (PDR). PDR programs, also known as purchase of agricultural conservation easement programs, pay farmers not to develop their land. The payment typically ref ects the difference between the value of their land for agricultural and developed use. The easement value (market value minus agricultural value) is determined either by appraisal or a numerical scoring system. PDR programs are voluntary with the payment based upon the parcel-specif c development premium. Presently, 14 states and 150 localities have PDR programs.

The particular set of farmland protection programs that exist in a given political jurisdiction are the result of decisions intended to protect benef ts of a public good nature. A limited number of studies have applied a "public choice" perspective to the analysis of such governmental decisions. The core idea is that voters support programs that maximize their utility (Stevens). In a sense, when choosing public goods, individuals partially act as consumers making choices affecting their own consumption of goods and service (Reichelderfer and Kramer), and partially as citizens expressing their values (Margolis, Quiggin). Analyses related to environmental issues show that bureaucrats are sensitive to questions of cost and benef t and to public input (Cropper et al., Yates and Stroup). Bureaucracies and legislative bodies also are responsive to the desires of their constituencies (Hewitt and Brown, Weingast and Moran). In each case, public preferences are being acted upon.

The positive externalities produced by PDR programs may explain their creation, which occurs primarily at the county or community level.[9] Recently, there has been research examining the public's perceptions of these programs. Kline and Wichelns (1994) investigated factors that comprise public support for PDR programs. They suggest (citing Gardner) that the public's objectives for preserving farmland fall into three categories: preserving agricultural resources, protecting environmental resources, and managing the growth of cities and towns. In a later study, Kline and Wichelns (1996) surveyed residents of Rhode Island regarding farmland preservation programs. Respondents were informed about these programs and then gave their opinions regarding the importance of 10 reasons to preserve farmland and open space. These preferences were then statistically grouped into four categories: environmental, aesthetic, agrarian, and antigrowth.

Modeling incentives for landowners to sell development rights has also been examined. The decision faced by a private landowner to convert his or her land to development in a given time period is similar to the rules governing optimal resource extraction (e.g., see Capozza and Helsley). Basically, the net returns from developing the parcel in some time period must exceed the present value of the parcel in an undeveloped state over future time periods (including possible gains from postponing development). Along the same lines, a landowner would sell the development rights to a parcel if the payment exceeds the expected gains from development less the use of the parcel in its present state.

Economic models have been used both to describe landowner incentives to join these programs and to identify the public's perception of PDR program benef ts. Little published research examines a third area of research: What factors motivate a political unit (e.g., county government) to create and manage a PDR program? Gardner argues against agricultural land retention policies utilizing a traditional, market-based approach. In this context, concerns over the development of farmland, or specif cally the lack of open space, is evidence of failure in the land market. Under this approach, Gardner argued, it makes little sense to use agricultural productivity as criteria to preserve land for environmental reasons. An alternative view is the institutional approach that recognizes the importance of nonmarket objectives and that the choice of the market system itself is an institutional decision made by the political process (Bromley). Although this approach lacks the formality and mathematical rigor of the traditional approach, it has the strength of explaining observed public sector behavior. The inconsistency between economic arguments and the political process could be explained by public ignorance regarding markets, or farmland preservation transcending eff ciency considerations. Mulkey and Clouser offer a synthesis of these two approaches. They advocate expanding the traditional market approach to include the institutional environment within which markets function and are deliberately selected as allocative mechanisms.

The Mulkey and Clouser synthesis is a plausible model of what occurs at the local level. As urban pressures increase and farmland is lost, local citizens become more concerned about preserving farmland, causing pressure for institutional change in local communities (counties). In the case of farmland preservation, citizens would initiate or demand county-level programs allowed by state-level farmland preservation programs or enabling legislation, to which county off cials eventually would respond. This response is the creation of a market for development rights as an allocative mechanism to preserve farmland.

In the next section, we investigate what factors appear to lead to such an institutional response. Given that such programs focus on farmland and potentially benef t farmers, we might expect both the amount of farmland and the rate of conversion to urban uses to be important. Population pressure would also play a role. As areas become more urbanized, the marginal value of undeveloped farmland grows. The rate of change of population pressure may also be important. Rapid, rather than gradual expansion in population, may spur the creation of PDR programs. Income is likely to play a role both in the demand for farmland preservation and the amount of land preserved. Environmental goods such as open space are probably income-sensitive luxury goods. Residents in counties with high income levels would be more likely to demand PDR programs. Income levels are also an indication of the tax base which would inf uence the amount of land preserved if the PDR program involves cost-sharing at the county level. These factors are assumed to inf uence both the creation of PDR programs and the amount of land preserved. However, some factors may be more important in explaining the creation of a program while other factors may be more important in explaining the amount of land preserved. The next section describes a two-part econometric model that f rst examines the existence of PDR programs and then examines the amount of land preserved conditioned on the existence of the program.

An Econometric Model of PDR Programs

In this section, a censored regression approach to identify factors that explain both the existence and magnitude of these programs is described. The analysis begins by examining whether a given land parcel (county) has a program. This is accomplished by estimating a probit model:

$$\text{Pr(PDR exists)} = 1 - \Phi(-\beta\mathbf{X}), \tag{2}$$

where β is a vector of estimable parameters, $\mathbf{X}$ is a vector of explanatory variables, and $\Phi(\cdot)$ is the standard normal cumulative density function. The probit model identif es factors that explain why a PDR program exists, but does not explain the amount of land preserved. To measure the amount of land preserved, denoted by y, the data is censored to only include observations where $y > 0$. To correct for this censoring, a variable often referred to as the "inverse Mills ratio" is computed from the probit model:

$$M = \varphi(\beta\mathbf{X})/\Phi(\beta\mathbf{X}), \tag{3}$$

where $\varphi(\cdot)$ is the standard normal probability density function. The censored least squares regression model to be estimated is

$$E(y \mid y > 0) = \Theta\mathbf{X} + \lambda M, \tag{4}$$

where Θ and λ are parameters to be estimated.

Data and Estimation

To conduct the analysis, county-level PDR data from seven of the most active states identif ed by Bowers are utilized. The data contain information regarding total preserved acres in each county since the inception of the PDR program (table 3). Although each of the seven states listed in table 3 has a statewide PDR program,[10] not every county in each state participates. Overall, about three-fourths of the counties across the seven states have PDR programs. Maryland and Pennsylvania account for well over half of the total acres preserved. To measure the intensity of the PDR programs, total acres preserved is indexed by county area (in square miles). Using this measure, Maryland has the highest level of preservation, distantly followed by New Jersey and Delaware.

The econometric model estimated here assumes that the existence of PDR programs depends on income, population density, and agricultural land density. Changes in these variables are also considered. As discussed in the preceding

Table 3. County-level PDR activity[1]

State	Total Counties in Each State	Counties with PDR Programs	Total Acres Preserved	Total Acres per Sq. Mile of Area[2]
Pennsylvania	67	37	106,481	4.31
Maryland	23	21	215,142	26.21
New Jersey	18	14	48,621	8.60
Massachusetts	14	11	39,350	4.92
Connecticut	8	8	25,483	5.30
Delaware	3	3	15,749	8.58
Vermont	14	14	65,935	7.68
Total	147	108	516,761	9.82

[1]Source: Bowers.
[2]Total acres preserved divided by total area (in square miles) of the counties practicing PDR programs.

section, these variables are hypothesized to be important factors that stimulate institutional change. County income data were gathered from the 1990 Census of the Population and Housing (U.S. Bureau of the Census, 1990). Higher levels of income are assumed to have a positive impact on the existence and intensity of farmland protection programs. Data on the density of agricultural land over time at the county level came from two (1987, 1997) Census of Agriculture surveys (U.S. Bureau of the Census, 1987, U.S. Department of Agriculture, 1997). Measures of both the present density of agricultural land and changes in the density are used in the model. Agricultural land density is the total area (in 1,000-acre units) of each county in agricultural land divided by the total square miles of county area. A high density of agricultural land is assumed to have a positive impact on protection programs. Reductions in agricultural land density, calculated as the 1987 density minus the 1997 density, are expected to positively affect the existence and intensity of these programs. As the amount of farmland lost increases, it is more likely that these programs will be initiated and more actively funded. Population pressure is measured by the urban influence variable described above in the benefits transfer section. Increases in urban influence, calculated as the 1970 level minus the 1990 level, are also included. Both of these variables are assumed to have positive impacts on the existence and activity of PDR programs. To account for regional variation, state dummy variables are included in both the probit and censored regression models.[11]

The first-stage probit estimates appear in the first column of table 4. In this portion of the model, mean income and agricultural land density are both statistically different from zero and have an anticipated positive influence on the probability that a PDR program exists. Both the urban influence and change in urban influence variables have unexpected negative signs, but are not statistically different from zero in all cases except one. The change in agricultural land density variable has the anticipated sign, but is not statistically different from zero. State dummy variables differ statistically in the model.[12] The estimated probit parameters were used to compute the inverse Mills ratio variable that appears in the censored regression model shown in the second column of table 4. In this model, all of the variables have the anticipated signs and are all statistically different from zero with the exception of the urban influence variable. As in the probit model, the state dummy variables are statistically different from one another. The inverse Mills ratio parameter (lambda), which corrects for censoring in the regression, is statistically different from zero. The fit of the equation (as measured by adjusted *R*-square) is good for cross-sectional data.

Examining the elasticities of PDR intensity with respect to the descriptive variables gives an indication of how changes in these variables impact the amount of land preserved.[13] Elasticity estimates appear in the last column of table 4. The elasticity of land preserved with respect to income is the largest elasticity estimate. This is not surprising since we hypothesize that open space preservation is a luxury good, and that luxury goods have elasticities greater than one by definition. The elasticities of land preserved with respect to urban influence and changes in urban influence are also large. These elasticities suggest that the concentration of farmland preserved in counties with PDR programs is quite sensitive to income and population pressure and changes in population pressure. The elasticities of land preserved with respect to agricultural density and changes in

Table 4. Sample selection model of PDR program activity with elasticity estimates[1]

Variables[2]	Probit[3]	Regression[4]	Elasticity[5]
MD dummy	−3.993 (−2.92)	−37.535 (−2.59)	–
PA dummy	−4.258 (−3.57)	−50.514 (−3.47)	–
NJ dummy	−4.571 (−3.05)	−50.376 (−3.15)	–
MA dummy	−3.825 (−2.56)	−45.325 (−3.40)	–
CT dummy	[6]	−43.344 (−3.22)	–
DE dummy	[6]	−46.937 (−3.28)	–
VT dummy	[6]	−32.910 (−2.97)	–
Mean income	0.123 (2.86)	0.853 (2.85)	4.964
Urban inf uence	−0.362 (−0.91)	4.194 (1.57)	2.485
Change in urban inf uence	−1.780 (−0.39)	102.670 (2.79)	0.614
Ag land density	4.510 (2.23)	63.202 (3.54)	0.322
Change in ag land density	10.563 (0.83)	170.638 (2.39)	0.260
Inverse Mills ratio	–	17.983 (2.46)	–
R-squared (adjusted)	–	0.520	–

[1]Two-stage censored model of PDR existence and intensity of land preserved.
[2]PA/MD/NJ/MA/CT/DE/VT dummy equal one if the observation is in PA/MD/NJ/MA/CT/DE/VT (respectively), zero otherwise. Mean income is the county mean income in $1,000 units. Change in urban inf uence is the change in the urban inf uence measure from 1970 to 1990 per square mile of county or state area. Urban inf uence is the 1990 urban inf uence variable. Ag land density is the density of farmland per square mile. Change in ag land density is the ag land area in 1987 minus the ag land areas in 1997 per square mile of county or state area. The inverse Mills ratio is calculated from the probit model. T-statistics for the null hypothesis that the parameter equals zero appear in parenthesis.
[3]Binomial probit model where the dependent variable equals one if the county has a PDR program, zero if not.
[4]Censored regression model where the dependent variables are average area (1,000 acres) preserved per square mile.
[5]Censored regression model elasticities where the dependent variable is average area (1,000-acre units) preserved per square mile.
[6]Because every county in these states has an active PDR program, a constant for these states cannot be estimated in the probit model.

agricultural land density are almost equal. This may indicate that land preservation is more sensitive to losses of farmland rather than the total amount available because changes in agricultural land per county (def ned as the loss of farmland from 1987 to 1997) is a much smaller number than acres of farmland in a county.[14]

Summary and Conclusions

Open space, either as farmland or undeveloped forestland, provides amenities to the public. In the case of farmland, several studies document the public's willingness to pay to prevent it from being developed for urban uses. Although no national estimates of this willingness to pay exist, our simple benef ts transfer exercise indicates that even under conservative assumptions, the benef ts are likely to be large and may outweigh the costs. As urban development spreads or sprawls far beyond city boundaries, the amenities provided by open space begin to disappear. To counter this, institutions have emerged and evolved to preserve these amenities. In the case of farmland, PDR programs have become increasingly popular. The programs compensate a landowner with a monetary payment equal to the premium associated with the development value of the land while leaving other ownership rights to the landowner. Market-based institutions such as PDR programs may offer a cheaper, more eff cient alternative than regulation or government activity (e.g., the Conservation Reserve Program).

An econometric model of PDR program existence and activity shows that average county income, agricultural land density, changes in agricultural land density, population pressure, and changes in population pressure are all important determinants of these programs and their levels of farmland preservation. These results have implications for several competing hypotheses regarding what motivates farmland preservation discussed in Adelaja and Friedman. Logan posited that "high status" communities undergoing rapid growth would have the necessary f nancial and social resources to motivate their citizens to demand farmland protection policies. Logan def ned a high status community as those with above average income, education, and home ownership.

The resource preservation hypothesis put forth by Gardner states that all motivations for these policies relate to open space. As open space decreases, the demand for it should increase. In other words, as more farmland becomes developed and areas become more congested, the concentration of farmland preservation should increase. Two later empirical studies by Kline and Wichelns (1994) and Furuseth did not f nd this to be true. In fact, these studies found that the strongest farmland protection policies exist in areas with abundant farmland. This led Furuseth to propose a "farmer political clout" hypothesis. Under this hypothesis, a positive relationship exists between farmland acreage and the demand for farmland retention due to farmers exercising political power.

Instead of conf rming one hypothesis and refuting the others, our f ndings support all three to some degree. The importance of the income variable, which has a large elasticity, partially supports Logan's "high status" community hypothesis. In terms of elasticities, the concentration of farmland preservation is most sensitive to income. The model's strong positive correlation between land preservation and population pressure, increases in population pressure, and reductions in farmland support Gardner's resource preservation hypothesis. At the same time, the positive relationship between the density of farmland and the amount of farmland preservation supports Furuseth's hypothesis of farmer political clout.

It is not surprising that the results support all three hypotheses since these factors are interrelated. As farmland is developed, it is likely that average income levels and community status of a given county rises.

Thus, a group of factors contribute to the existence of PDR programs. On the demand side, there needs to be a certain level of wealth and urban pressure. On the supply side, there must be a critical mass of farmland present to initiate and sustain a preservation program. The analysis in this paper is limited to the northeast states, where these conditions are prevalent. An increasingly aff uent and growing population is responsible for the rapid development of open space. Segments of this population have expressed their desire to preserve open space using PDR programs. Where does the future lie for PDR programs? PDR programs will probably not appear in slow-growing areas with a large amount of agricultural land. Regions of the country experiencing rapid growth in population and income coupled with rapid development of open space (e.g., Florida) or near large cities are likely candidates for future PDR programs.

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Endnotes

[1]Several examples include: St. Louis, where developed land increased by 355% while population increased by just 35% from 1950 to 1990; Kansas City's population grew by 29% while developed land increased 110% from 1970 to 1990; Philadelphia's population grew 2.8% while developed area increased 32% from 1970 to 1990; the Chesapeake Bay watershed's population rose 50% while developed area increased 180% from 1950 to 1980. In Chicago, whose metropolitan area covers 3,800 miles, land developed for housing grew 46% while population grew only 4% over the last decade (U.S. Congress).

[2]The 1996 Farm Bill (P.L. 104-127) included $35 million in grants to state and local governments. The 2002 Farm Bill (P.L. 107-171) authorized nearly $600 million for the Farmland Protection Program through FY 2007. In New Jersey, the 1999 Garden State Preservation Trust Act allows New Jersey to preserve one million acres over the next 10 years. The amendment dedicates $98 million annually for 10 years dedicated to preservation efforts and authorizes the issuance of up to $1 billion in revenue bonds. Pennsylvania has funded farmland preservation through a tax levied on the sale of cigarettes. In 1999 alone, $28 million of tax revenues was used to purchase easements. Counties must provide matching funds in order to receive state funding.

[3]Kline and Wichelns (1994) examined factors that explained the existence, but not the size of these programs. The model used in this paper expands upon that study and is applied at a regional rather than localized area.

[4]This variable (used by Barnard et al.) is important later in the analysis. It takes into account both the density and proximity of population in a specif c area using a gravity measure similar to one used by Shi, Phipps, and Colyer. The variable itself is derived from the 1990 Census of Population and Housing (U.S. Bureau of the Census, 1990) data using a function in the ARC/INFO GIS software package. Inf uence categories are def ned by quartiles.

[5]This includes the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, and Vermont. Note that open space in the low and medium urban inf uence areas of these states is valued using the Bergstrom, Dillman, and Stoll estimate of $0.21 per 1,000 acres.

[6]These market values were inf ated to year 2000 prices using changes in farmland value data supplied by the USDA National Agricultural Statistics Service.

[7]The pasture and forest categories are aggregated due to low number of observations for these categories in some states.

[8]These willingness-to-pay numbers do not include off-site damages that result from construction such as the reduction in surface water quality caused by erosion from construction sites. It is well known that clearing land for construction causes signif cant erosion. This run-off diminishes the quality of nearby lakes and streams that are used for recreation. Although these damages are short lived (1–2 years), they are potentially signif cant and could be estimated using benef t a benef t function transfer using a model such as one used by Feather and Hellerstein.

[9]Individual local communities (usually counties) must take the initiative to create, manage, and often partially fund a PDR program.

[10]In some states, the programs are funded at the county level with the state merely providing enabling legislation. In other states, there are state-funded programs in which counties can choose to participate.

[11]These variables capture state-level characteristics. One important effect they account for, especially in the second stage portion of the models, is the length of time the programs have existed, which varies across states, but not across counties within a state. The states of Connecticut, Delaware, and Vermont all have 100% participation at the county level. Dummy variables for these states cannot be estimated in the f rst stage probit model.

[12]A likelihood ratio test showed signif cant statistical differences between the state dummy variable parameters. Note that because all counties in Connecticut, Delaware, and Vermont have active PDR programs, the dummy variable parameters for these states cannot be estimated.

[13]Elasticities measure the percent change in the independent variable resulting from a 1% increase in the dependent variable. In the censored regression model, the elasticity of dependent variable Y with respect to independent variable X, E_{yx}, is

$$E_{yx} = \partial E(Y \mid Y > 0)/\partial X * X/Y = (\Theta + \lambda * \partial M/\partial X)\{X/E(Y \mid Y > 0)\},$$

where Θ is the regression parameter of X and λ is the parameter associated with the Mills ratio (M) def ned above. The derivative of M with respect to X is approximated numerically by increasing X by 1% and calculating the change in M.

[14]On average, agricultural land density is 0.151 (thousand) acres per square mile of county area. Changes in agricultural land density average 0.016 (thousand) acres per square miles of county area.

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